Some EFB solutions offer connectivity to aircraft avionics and/or back-office systems. This can increase efficiencies in operations and maintenance. The main options for connecting EFBs are examined here.

Methods for establishing EFB connectivity to avionics and the back-office

Airlines are increasingly aware of the potential cost and efficiency benefits of adopting an Electronic Flight Bag (EFB) solution.

Initially the business case for introducing EFBs focused on the weight-saving benefit of replacing the contents of a pilot's flight bag with electronic versions of manuals, charts and forms.

Developments in hardware and software have led to additional advantages in the form of EFB connectivity. Various methods have been established for connecting EFBs, both to aircraft avionics and to back-office systems. This allows an EFB solution to integrate the flightdeck into an airline's central IT system and workflows. The advantages of this can be efficiency benefits in areas including operations and maintenance, aircraft loading, airport operations, fuelling and ground-handling.

The methods and comparable costs for establishing connectivity between EFBs and aircraft avionics and back-office systems are examined here.

EFB Classifications

An EFB is a flightdeck tool that combines software with electronic visual display hardware to perform operational functions that were previously carried out using paper or manual processes.

EFB hardware has traditionally been classified as Class 1, 2 or 3; while software has been identified as Type A, B or C. Continuous developments in EFB design and capability mean that these distinctions are changing. In the future, EFB solutions will be classified as portable or installed. Only Type A and B software will be considered as providing an EFB function.

New guidelines reflecting these changes are expected in 2014.

EFB Hardware

Class 1 EFB devices are often consumer-off-the-shelf (COTS)-based portable electronic devices (PEDs), such as laptop or tablet computers. They are not fixed to an aircraft and have no data connectivity with aircraft systems. They can host Type A and B software and do not require airworthiness approval. Some aviation authorities now permit the use of Class 1 devices in all phases of flight providing that they are appropriately secured and viewable.

Class 2 hardware can also be COTS devices and are often portable. They can be attached to a flightdeck mounting for use in all phases of flight and support Type A and B software. Class 2 devices can send and receive data from aircraft systems via a piece of intermediary equipment known as an Aircraft Interface Device (AID). Airworthiness approval is required for the flightdeck mounting and AID.

Class 3 devices are installed avionics equipment that can support all software types. They need airworthiness approval.

EFB Software

Type A software, like a document reader, is pre-composed and non-interactive.

Type B software can be dynamic and interactive, and uses data for operational requirements. Examples of Type B applications include an Electronic Technical Log (ETL), electronic aeronautical charts, performance calculation tools and flight operations manuals.

Type C software provides communication, navigation and surveillance avionics functions. An example would be Controller Pilot Data Link Communications (CPDLC).

Type C software requires airworthiness approval, but Types A and B do not.

Connecting to avionics

There are EFB solutions that provide connectivity to aircraft avionics. Some only permit data to be received from aircraft systems. Others offer the possibility of two-way data exchange across the aircraft databuses.

The ability to download data from aircraft systems allows EFB applications to be populated with live data, including Flight Management System (FMS) position information or other operational and maintenance-related parameters. This can reduce the time and errors associated with manual data-entry. It can feed applications with the most current and accurate parameters available.

The capability to upload information from an EFB to aircraft systems might permit data from performance calculation applications to be fed into the FMS. These data might be used to specify the optimum flight trajectory to minimise fuel consumption.

Another advantage of connecting an EFB solution to aircraft systems is that it can open up the various aircraft communication channels as options for sending data from the EFB to back-office systems.

Previously, the level of potential connectivity between an EFB and aircraft avionics has been dependent on the class of EFB solution. As the classifications change to a distinction between portable and installed, it will be the type of EFB software and the functions it is used to perform that will determine whether the EFB solution is permitted to connect.

Under the existing classifications, Class 1 solutions do not have approval to connect to aircraft avionics. This is changing. Under the new guidelines Class 1 solutions will be classified as portable devices. Teledyne Controls is a provider working on a method for connecting such a solution to aircraft avionics.

Class 2 solutions are able to connect to aircraft avionics and receive data from them. Some Class 2 solutions are allowed to upload data to aircraft systems.

Class 3 solutions are part of the aircraft's certified avionics. This means they can exchange data to and from other avionics systems.

The majority of avionics data on commercial airliners is transmitted across ARINC 429 databuses. To access avionics data, an EFB needs to be connected to the required A429 databus. For those non-Class 3 EFB solutions that are not considered part of the aircraft's certified avionics, the connection has to take place via the AID. The AID allows data to be sent between the databus and EFB, while maintaining a certified partition between them. AIDs are normally a separate avionics box which interfaces with an A429 bus via a hard-wired connection.

Communication between an EFB and an AID can be established via a hard-wired Ethernet connection. For EFB devices without Ethernet ports, solutions are being developed for connecting to an AID using Wi-Fi or Bluetooth.

A number of vendors that provide flightdeck-tailored Class 2 and 3 EFB hardware have adapted their product portfolio given the growing popularity of COTS-based solutions. Many now offer integration solutions for COTS-based EFBs alongside their traditional hardware. These solutions often include some form of mounting device and AID, and allow the COTS hardware to connect to aircraft systems. Companies providing COTS integration products include navAero, Astronautics, CMC Electronics, UTC Aerospace and DAC International.

Via its Wireless GroundLink® Comm+ (WGL Comm+™), WGL-Fi™ and WGL-AID™ products, Teledyne Controls has developed a method for EFBs to access data from aircraft avionics via a wireless connection to an AID. The WGL-Fi™ system provides a Wireless Access Point (WAP) on the flightdeck. This allows a WiFi-capable EFB device to connect to the WGL Comm+™ unit. The WGL-AID™ is a software solution that sits on the WGL Comm+™ and provides certified connectivity to aircraft avionics. The WGL Comm+™ is already used by airlines, and the WGL-Fi™ and WGL-AID™ solutions will see their first installations in 2014.

Class 3 EFBs are hardwired directly to the aircraft databuses. As part of the certified avionics they are not required to connect to an AID for two-way data exchange between certified EFB software and aircraft systems. The interface function is performed within the avionics architecture. Class 3 EFBs are most common as line-fit devices in new aircraft such as the 787. They will often be delivered with manufacturer's software, such as performance calculation applications. This software is considered part of the certified avionics. Some Class 3 devices include a partition which allows them to host certified software and non-certified Type A and B applications. This would allow for additional non-certified applications to be added to the EFB, but these would not be permitted to connect to aircraft avionics.

Connecting to the back-office

The methods available for exchanging data between an EFB and back-office systems depend upon the type of communication being sent and whether the EFB solution is connected to aircraft avionics. There are different flightdeck communication categories, protocols and media to consider.

Communication categories

There are four main categories for communication to and from the flightdeck: air traffic services (ATS) messages for safety-of-flight-related air traffic control (ATC) functions; airline operational communication (AOC) messages; airline administration communication (AAC) messages; and air passenger communication (APC) messages.

Most EFB-related communications are considered to be AOC and AAC. "These are not safety-of-flight-related and do not need to be sent using safety-of-services approved connectivity systems," explains Sean Reilly, a director of product marketing for L3 Aviation Products. "Other connectivity methods may be used for AOC and AAC communications, if approved by the governing authority of the airline."

AOC messages relate to aircraft and airline operations. When an EFB transmits or receives operational or maintenance data it would be considered an AOC message. Examples include sending live weather updates and revised flight plans to an EFB. Other data, including completed forms and reports,

An aircraft interface device (AID) is required to connect a Class 2 EFB to the aircraft's systems, so that the EFB can send and receive data from the aircraft's avionics, such as the flight management system (FMS).

such as load sheets and ETL records might be sent from an EFB to back-office systems when in flight or at the gate. This level of connectivity could allow engineers to prepare in advance for potential fault rectification.

AAC messages involve the administration processes that make operations possible, including managing libraries and databases. Sending updates of electronic manuals, charts and forms to an EFB would be considered as AAC messaging. This is more efficient than paper updates, taking less time and requiring fewer staff.

Some installed Class 3 EFBs are now capable of hosting ATC-related software functions such as CPDLC. These are considered to be safety-of-flight-related. Any safety-of-flight-related ATS messages have to be sent via certain approved connectivity systems. As ATS messaging is not a principal EFB function, it does not form the focus of this analysis.

Communication protocols

There are two main communication protocols available for exchanging data between EFBs and back-office systems: aircraft communications addressing and reporting system (ACARS) protocols or Internet Protocols (I.P.) Only EFB solutions with a certified connection to aircraft avionics can send data via ACARS.

ACARS is the main format used for sending flightdeck data messages while airborne. There are two standards of ACARS data transmissions. The first is often known as plain old ACARS (POA). POA is a character-oriented protocol (COP) that can send analogue messages via radio and satellite communication (Satcom). It is limited to a transition rate of 2.4 kilobits per second (Kbps).

The second standard of ACARS is bit-oriented protocol (BOP) transmissions. These are binary files that contain more information than POA messages, and can only be sent using second-generation VHF (very high frequency) digital radio. This is referred to as VDL mode 2 (VDL M2) ACARS. These messages are transmitted at a rate of 31.5kbps.

There are two types of VDL M2. One sends messages via the Aeronautical Telecommunications Network (ATN) and is known as ATN VDL M2. The ATN provides common services and protocols which air-to-ground, ground-to-ground and avionic sub-networks can use to communicate with each other. The only current application for ATN VDL M2 is for sending CPDLC messages, which replace voice communications between pilots and air traffic controllers in the upper airspace of certain global regions.

The second type of VDL M2 ACARS messages does not use the ATN network. This is known as ACARS via aviation VHF link control (AVLC) or AOA. AOA is used for VDL M2 messages with the exception of CPDLC.

ACARS messages adhere to ARINC standards designed to guarantee certain levels of reliability and consistency. They are an approved method for sending ATS messages, but are also used for AOC and AAC messages.

I.P. systems provide larger and faster data transfer rates, but are not currently approved for sending ATS messages. AOC and AAC data can be sent using either ACARS or I.P. protocols.

A new method of sending large volumes of data called Media Independent Aircraft Messaging (MIAM) is currently in development. It is based on AEEC 841 standard. "MIAM allows avionic systems to exchange large volumes of data, larger than the maximum ACARS message size," explains Mario Sabourin, senior product manager EFB at SITA. "MIAM allows these data to be exchanged over ACARS and broadband I.P. subnetworks."

There are a number of connectivity systems available for ACARS and I.P. data transfer.

Communication media

The connectivity systems available for establishing communication between an EFB on the flightdeck and back-office systems fall into three main groups: radio transmissions; Satcom; and ground communications.

EFB data can be sent while airborne using ACARS over radio and Satcom.

Only EFB solutions that are connected to the equivalent of the communication management unit (CMU) on Boeing aircraft and the air traffic service unit (ATSU) on Airbus aircraft, can use ACARS over radio and Satcom to transfer data between EFBs and back-office systems.

This connection would take place via an A429 databus. Those non-Class 3 EFB solutions that are not considered part of the aircraft's avionics would need to interface with the databus via an AID.

EFB data can also be sent in the air using I.P. over Satcom. I.P.-based Satcom solutions were initially developed to provide cabin connectivity functions, but are now being appropriated for flightdeck AOC and AAC messaging purposes.

Another potential airborne communication media for EFB data is under consideration in the US, where there is already infrastructure in place to provide I.P. connectivity using cellular signals. Companies such as GoGo have developed cabin connectivity solutions using ground-based cellular towers to send and receive data from aircraft. Now airlines are keen to explore the possibility of connecting their EFBs to such networks for AOC- and AAC-related data exchange.

When on the ground there are a number of I.P.-based communication options for exchanging data between EFBs and back-office systems.

American Airlines operates an iPad-based Class 1 EFB for the whole of its fleet. American was the first airline to receive approval for the use of Class 1 EFBs for all phases of flight.

Many airlines use ground-based I.P connectivity systems such as cellular and Wi-Fi to transfer data to and from EFBs while the aircraft is at the gate. Some also use USB or flash drives, while those with tablet- or laptop-based solutions can also update their EFBs outside the flightdeck using WiFi in the crew room. Ground-based methods tend to be cheaper and have higher data transfer capability than airborne radio and Satcom methods. EFBs do not require a certified connection to aircraft avionics to send data via these ground-based systems.

Radio transmissions

EFB solutions with the appropriate avionics connections can send AOC and AAC messages via POA over VHF, and AOA using VDL M2. VHF radio can only be used within range of ground-based VHF radio transceivers. VHF transmissions have a range of up to 200nm, so this method is not an option for oceanic routes. VDL M2 coverage is not yet available in all regions.

EFBs with a certified connection to aircraft avionics can also send data via POA over High Frequency (HF) datalink (HFDL). HF radio bounces transmissions off the ionosphere to provide a range of several thousand miles, but this approach has its drawbacks. "HFDL has a single supplier and from experience can prove problematic due to the long range and poor quality of the signal," claims Murray Skelton, director of business development, at Teledyne Controls. "It is also a very expensive service and can cost more to use per kb of data than Satcom."

Most airlines would only use ACARS for relatively short AOC or AAC data messages between EFBs and back-office systems. This may be due to cost and transfer rate considerations.

Satcom

EFBs can use a number of Satcom systems to provide back-office connectivity, including Inmarsat Classic, Iridium, Inmarsat Swiftbroadband (SB) and various Ku band providers.

EFBs with certified connections to aircraft avionics can send AOC and AAC data via Inmarsat Classic and Iridium. The data would be sent over these Satcom pipes via POA.

"It is also possible to have a direct Ethernet connection between an EFB and the Iridium box," explains Reilly. "A piece of software sits on the EFB device, and allows it to send AOC and AAC messages using I.P. protocols and the Iridium pipe."

Inmarsat Classic is an L-band satellite solution that provides coverage for 99% of commercial flights. Only the polar regions are not covered. Inmarsat Classic's transmission rate for ACARS messages is 2.4kbps.

Iridium provides 100% global coverage and it is hoped that the next generation of this system (Iridium NEXT) will provide a significant increase in bandwidth. "The current Iridium solution has a native bandwidth of up to 2.4kbps per channel, but some systems claim to achieve 9.6kbps via software compression," says Skelton. "In terms of cost, sending POA messages over Iridium is now as cheap as using VHF."

Inmarsat SB and Ku Band Satcom systems have higher transfer rates and are based on I.P. protocols.

Inmarsat SB still uses L-band transmissions and has similar global coverage to the Classic product, but has a transfer rate of 432kbps.

Ku band solutions provide data transfer rates of 2-6 Megabits per second (Mbps), but coverage can be regionalised.

Using Inmarsat SB or Ku band Satcom, EFBs can send non-ACARS airborne AOC and AAC I.P. communications. "This requires an I.P. interface from the EFB with suitable security and authentication to a suitable Satcom LRU," explains Skelton. In many cases this may not require additional certification, because the I.P. services on these devices have been designed for non-certified I.P. communications.

A number of solutions that will allow ACARS messages to be sent over I.P.-based Satcom systems are being developed. This would require a certified interface between the EFB and aircraft avionics.

Ground communications

The two main ground-based data transmission systems for exchanging AOC and AAC data between EFBs and the back-office are Gatelink WiFi and cellular. Others include transferring data with USB drives and via Bluetooth.

Gatelink WiFi requires WiFi access infrastructure to be installed at all gates at the airport. "In theory its bandwidth is 300Mbps plus, but WiFi is a shared service and connection speed varies depending on the number of users. So you need a good infrastructure to support higher speeds," says Skelton. "Gatelink WiFi has not proven as popular as originally expected. It soon became clear that the cost of WiFi-enabling an airport so that all gates had access was prohibitively expensive in a lot of cases."

WiMax is another communication option. "WiMax is a more capable WiFi service with faster data transfer speeds," explains Reilly. "A WiMax antenna can connect within a 5-10 mile radius of the signal. WiMax networks are generally private and used for uploading large in-flight entertainment (IFE) content, but some airlines also use it to transfer data between EFBs and back-office systems."

Unlike WiFi, cellular connectivity does not require additional or new ground infrastructure. The EFB just needs to connect to existing cellular networks. This is one of the most popular methods of communication between EFB and back-office today.

There are three different standards of cellular network: 3G, 4G and LTE. At this time 3G is the most widely available. "3G is suitable for short burst type messaging with small packets of data," says Reilly. "4G can process larger packets, and LTE larger still."

"Data transfer rates using 3G are reliably 8-9 Mbps on clean low congestion networks and 1-4 Mbps on congested networks," says Skelton. "Transfer rates on 4G and LTE can vary from 75-300 Mbps depending upon the level of network congestion."

Some EFB devices will have built-in wireless capability or SIM cards that allow them to connect to Gatelink WiFi or cellular networks independently of aircraft systems. It is also possible to connect to Gatelink WiFi and cellular networks via aircraft systems.

Modern aircraft, including the A380, A350, 747-8 and 787, have an avionics architecture which includes an on-board network server unit. This, along with a WiFi antenna and a terminal wireless lan unit (TWLU), allows these aircraft to connect to Gatelink WiFi and exchange information, such as engine health monitoring (EHM) and aircraft health monitoring (AHM) data. Via an ethernet connection to the TWLU or similar device, EFBs can use Gatelink WiFi systems to exchange data with the back-office. Suppliers of TWLUs include Miltope, Honeywell, Rockwell Collins, Thales and Teledyne Controls.

It is also possible to connect an EFB via Ethernet to an avionics ground link device for cellular connectivity. "This can provide a more reliable connection than simply using the installed cellular card on the EFB device," says Skelton. Teledyne's WGL Comm+™ has multiple cellular radios with I.P. data transfer speeds of up to 48Mbps for 3G and 300Mbps for 4G per radio. "Cellular is currently the cheapest broadband data service available to airlines and it's getting cheaper," claims Skelton. When Teledyne's WGL-Fi™ product becomes available it will be possible for EFBs to connect to the WGL Comm+™ wirelessly.

Some suppliers provide dual WiFi and Cellular ground-link capable units.

Communication costs

In general it is cheaper for airlines to send EFB data via ground-based, rather than airborne communication methods. Ground-based systems also tend to offer greater data transfer capability.

Where airborne communication is concerned, it can be difficult to compare the cost of using ACARS over radio or Satcom. Costs for ACARS over VHF or HF are character-based, while Satcom is charged for in terms of the number of data packages sent in a given time period. Using I.P. over Satcom can be more expensive than ACARS messages because larger amounts of data are involved.

For ACARS messaging, the CMU in Boeing aircraft and the ATSU in Airbus aircraft can be programmed to select the cheapest connectivity channel available for flightdeck communications.

As part of its AS-FlightBag 3.0 EFB software product Aircore Systems has developed its Communication Efficiency Optimiser (CEO) module. This selects the most suitable communication channel for EFB data, based on message criticality and the cost of the available channels. It is designed to provide lower communication costs, an increase in the availability of relevant data and more automated process for back-office connectivity.

"We saw the potential for major airline cost savings by getting away from expensive, Satcom-orientated data dumps," says Michael Rosenkranz, chief executive officer at Aircore Systems GmbH. "Many of these data never see the light of day after being entered into the airline repository. Airlines need to manage these data in terms of criticality and cost."

Croatia Airlines is in the process of replacing a Class 1 EFB system with a Class 2 solution. The main objective for the airline is to connect the EFB to its back-office systems. The Class 2 EFB is based on a Samsung PC notebook, which has a detachable keyboard.

Airline case studies

A series of airline case studies have been included to identify if, how and why different carriers have established connectivity between their EFB solutions and aircraft avionics, and/or back-office systems. The case studies cover a mix of scheduled and charter airlines that between them operate widebody, narrowbody and regional aircraft.

American Airlines

American Airlines currently operates a fleet of more than 600 mainline aircraft including MD-80s, 737s, 757s, 767s, 777s, A319s and A321s. As a result of its merger with US Airways, the new American will be one of the largest airlines in terms of fleet size.

American Airlines operates an iPad-based, Class 1 EFB solution across its fleet. It was one of the first airlines to receive approval for the use of a Class 1 system in all phases of flight.

The EFBs host Jeppesen electronic chart software and a PDF document viewer called GoodReader. This has an in-built browser, allowing pilots to download documents from the airline's flight department website. American is in the process of transitioning to a 'purpose-built' browser provided by Comply365.

"During the merger process, as we are harmonising systems, US Airways will adopt an EFB solution as close to American's existing Class 1 set-up as possible," explains Captain David Clark, senior manager of flight operations efficiency and quality assurance at American Airlines. "The most significant difference will be that the US Airways aircraft will be issued with iPad Airs, instead of iPad 2s."

American's EFBs do not connect to aircraft avionics. The airline does have ground-based connectivity solutions in place for exchanging data between the EFB and back-office while at the airport gate.

"We have WiFi and Cellular connectivity options at the airport gate," says Clark. "WiFi is the primary means for sending EFB data with cellular used as a back-up. Connectivity with back-office systems brings advantages in terms of accuracy, efficiency and cost-effectiveness."

"We use WiFi because the infrastructure was already available at a lot of our bases and main hubs," continues Clark. "There are occasions where, depending on the positioning of the wireless router in the terminal, we can lose the WiFi signal on the flightdeck. It is also expensive to build additional WiFi infrastructure at airports. It is possible that in the future cellular connectivity will become a less expensive primary option for us than WiFi. Cellular connectivity will certainly become more attractive as 4G/LTE broadband capability becomes more widely available."

American's iPad EFBs use SIM cards and in-built capability to connect to WiFi and cellular networks at the airport gate.

Croatia Airlines

Croatia Airlines is the Croatian flag carrier and is based in Zagreb. It operates a fleet of 12 aircraft including two A320s, four A319s and six Q400s. It currently has a Class 1 EFB solution in operation, but is in the process of replacing this with a more capable Class 2 system.

"The main goal of implementing the Class 2 solution is to increase operational efficiency and the ability to connect the EFB in the flightdeck to back-office systems," explains Mario Misic, EFB project manager at Croatia Airlines. "The current Class 1 system includes Electronic Flight Folder (EFF), document viewer and performance calculation software functions. The EFBs are pilot-allocated and updated in the office or briefing room using company network or USB drives."

Croatia Airlines' Class 2 EFB solution will be implemented in two phases. The first phase is due for completion in April 2014. It will include the installation of new hardware in the form of a Samsung PC notebook, which has a detachable keyboard that allows it to function as a notebook or tablet. Croatia Airlines will run Windows 7 on these devices with two being issued to each aircraft. The Samsung notebooks will be attached to the aircraft by certified navAero mounting devices. In Phase 1 they will host the EFF, performance calculations and document viewer applications provided by Flightman, along with Lufthansa Systems Lido/eRoute Manual electronic aeronautical charts.

The second phase of the new EFB solution is due to be in operation by the end of 2014. This will see further Flightman software modules added, including the eJourney Log, Weight and Balance, Large Content Manager and Business Intelligence Tool. This phase of implementation will also involve the integration of the EFB solution with the airline's back-office systems.

"Our EFB system is populated with data from back-office systems such as flight planning, operations and maintenance," explains Misic. "Currently we only have a one-way dataflow to the EFB. The Class 2 system will also allow for data to be sent from the EFB. To improve operations it is crucial to retrieve as much data as possible from the flightdeck. With a connection to back-office systems you can evaluate and correct data which can lead to improved safety and reduced costs."

At this time the airline has no plans to connect the Class 2 EFBs to aircraft avionics, ruling out aircraft-based communication options such as ACARS over VHF or Satcom.

"We have chosen ground-based cellular connectivity as the preferred

Thomson Airways has Class 3 EFBs installed on its 787s, and Class 1 EFBs through Panasonic Toughbooks on its 737-800s, 757s & 767-300ERs. This Class 1 system will be replaced by a Class 2 EFB, based on navAero hardware. Pilots will also be issued with tablet devices.

method for integrating the Class 2 EFBs with back-office systems," explains Misic. "The Samsung notebook hardware will have SIM cards installed to provide cellular connectivity when the aircraft is on the ground."

Misic lists a number of reasons for selecting cellular over Wi-Fi. "Cellular connectivity is cheaper for our needs than WiFi," he says. "We would face the added cost associated with the rental of third-party routers with WiFi. The cellular network is also available in most locations and in some cases can be faster than WiFi."

Thomson Airways

Thomson Airways is a UK-based holiday airline. It has a fleet of 58 aircraft, comprising 737-800s, 757s, 767-300ERs and 787-8s.

Thomson Airways has two separate EFB solutions: one for the 787 and another for the rest of the fleet. "The 787s have been delivered with an installed Class 3 system," explains Phil Ganewski, manager flight support at Thomson Airways. "From an EFB perspective we decided to treat the 787 separately from the rest of the fleet to avoid adding extra complexity while introducing a new aircraft type."

The airline has been operating a pilot-issued Class 1 EFB system on its 737, 757 and 767 aircraft for about 10 years. This is soon to be replaced by a Class 2 system.

"The current Class 1 solution uses Panasonic Toughbooks and in-house software," explains Ganewski. The software functions include electronic manuals, take-off performance calculators, operational information and an electronic journey log. The Class 1 system is not connected to aircraft systems and cannot exchange data with back-office systems from the flightdeck.

Thomson Airways' Class 2 EFB solution will consist of navAero t.Bag^{TM}C2^2 hardware with a hardwired connection to an AID, providing connectivity with aircraft systems. This will be for one-way data flow only, from the avionics to the EFB.

Two navAero t.Bag^{TM}C2^2 EFBs will be issued to each aircraft, while separate, tablet-based devices will be issued to each pilot, replacing some of the functionality of the current Class 1 Panasonic laptops. These will allow flightcrew to access some EFB applications when away from the flightdeck.

Initially Thomson's Class 2 solution will host Jeppesen's FliteDeck Pro aeronautical chart application, and Boeing's On-board Performance Tool (OPT), which includes take-off and landing performance calculations. It will also include Arconics' AeroDocs electronic manuals software module. The EFB shell application will be provided by AvioVision's AVIOBOOK®. This first stage of implementation is due to be completed by March 2014. The next stage could involve the implementation of an electronic flight folder and ETL in 2015.

"The main business drivers behind the move to a Class 2 solution were the desire to eliminate paper charts, and the addition of connectivity to aircraft and back-office systems," says Ganewski. "This will bring the rest of the fleet more in line with the capabilities of the 787.

"The advantage of having connectivity with aircraft avionics is that real-time data such as GPS position information, speed and altitude, can be fed into the EFB and used in the various software applications," says Ganewski. "For example fuel burn data can be used to populate a report in an EFB, which is then sent to back-office systems."

With connectivity to aircraft avionics, Thomson's Class 2 solution has the capability to exchange data with back-office systems via ACARS. "For small pieces of data ACARS is an option, but for any significant data exchanges we will use ground-based communication," says Ganewski.

Thomson's Class 2 EFBs will be equipped with a 3G SIM card and use ground-based cellular networks as the main method for exchanging data with back-office systems.

"We selected cellular over Wi-Fi for the Class 2 EFBs, because it was more flexible for our business model," says Ganewski. Thomson's aircraft often park at remote stands where there may not be any Wi-Fi infrastructure or where the Wi-Fi infrastructure is owned and controlled by third parties.

"An advantage of connecting the EFB to back-office systems is that this allows the EFB to be remotely controlled," say Ganewski. "Also data gathered from aircraft avionics can be sent straight to back-office systems, saving time."

Thomson Airways currently has four 787-8s in its fleet, with four more on order. These have been delivered with an installed Class 3 EFB solution which includes Jeppesen electronic charts and Boeing manuals and performance calculation software.

"The Class 3 system in the 787 is a fully integrated part of the aircraft's avionics," explains Ganewski. "This enables two-way communication between the EFB and other aircraft systems." Data from the FMC can be fed into a performance calculation application and the resulting numbers are fed back into the FMC to provide optimum performance parameters while eliminating manual transcription errors.

The Class 3 EFBs on Thomson's 787s can send data to back-office systems via ACARS over VHF, HF or Satcom.